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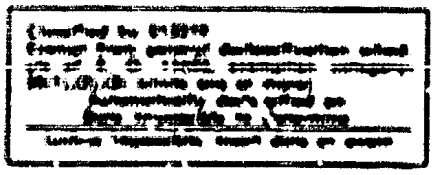
The Soviet Grain Situation in Fiscal Year 1974
A Preliminary View



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The Soviet Grain Situation in Fiscal Year 1974
A Preliminary View

Introduction

1. For the third time in a decade the USSR has become a major factor in the world market for wheat and coarse grains. During fiscal year (FY) 1973,[1] scheduled Soviet purchases of 26 million metric tons of grain will account for more than one-fifth of world imports of all grains (including rice). The FY 1973 imports are about three times as much as the USSR bought in FY 1964 and FY 1966 after similar shortfalls in domestic production. Moreover, this year, unlike in the earlier years, nearly two-thirds of the purchases were made in the United States.

2. Because US agricultural programs and policies must take into account potential grain exports, the outlook for Soviet grain imports is of major concern. The purposes of this paper are to (a) project likely levels of Soviet grain

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Note: Comments and queries regarding this paper are welcomed. They may be directed to [redacted] of the Office of Economic Research, Code 143, Extension 6576.

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1. The fiscal year ends on 30 June of the stated year.

production in 1973 on the basis of trends in yields of individual grains and (b) estimate probable domestic requirements for grain and provide a conditional forecast of Soviet grain imports in FY 1974.

Principal Findings

3. A forecast of Soviet grain production in 1973 was obtained by extrapolating yields based on trends observed from 1958 to 1971. Under the most likely pattern of harvested acreage in 1973, the simple projection of yield trends implies a point estimate of output of 152½ million tons. Although the chances are two out of three that total grain output would lie within a range from 133 million to 172 million tons, there is one chance in six that the crop will exceed 172 million tons and one chance in six that it will be less than 133 million tons. The high degree of uncertainty in the projection of output reflects the wide fluctuations in yields in the past. Soviet grain output is perhaps more strongly influenced by year-to-year changes in growing conditions than that of any other major world producer.

4. A projection of domestic utilization of grain can be based on trends in those uses that

can be estimated with a fair degree of reliability (food, seed, and industrial uses), on an analysis of the likely requirement for livestock feed, and on an allowance for waste and changes in stocks. The use of grain in FY 1974 for food, seed, and industrial use is expected to be almost 87 million tons -- not very different from the levels of recent years. The demand for grain for livestock feed on the other hand, will probably increase between 5 million-10 million tons to a level of 67½ million-72½ million tons. (This range reflects alternative strategies in expanding herds in calendar year 1973.) Assuming no change in inventories and a wastage of 5 million tons, total domestic requirements would amount to 159 million-164 million tons. If, as seems likely, the USSR is unable to cut its grain exports in FY 1974 below the FY 1973 level, the Soviet requirement for grain for both domestic uses and export would be about 165 million-170 million tons.

5. A comparison of the projected supply of grain under normal weather conditions (152½ million tons) and the expected demand for grain (165 million-170 million tons) implies a Soviet need to import about 12½ million-17½ million tons of grain in FY 1974. Should the USSR attempt to rebuild depleted carryover stocks of grain, the import requirement would rise accordingly. A crop of less than 140 million tons -- a

distinct possibility given the wide range of possible yields -- would probably force the leadership to make painful adjustments in its present farm and consumer policies.

Conditional Forecast of Grain Production in 1973

6. Forecast yields for 1973 were obtained by extrapolating from a linear time trend fitted to reported yields for each of 11 grains and pulses in the 14 years 1958-71.[2]

7. Forecasts of production were obtained by multiplying forecast yields by estimates of the 1973 harvest area. The total harvest area of 121.5 million hectares (see Table 1) includes 22.0 million hectares of winter grains and 99.5 million hectares of spring grains. The winter grain area is one of the lowest on record, primarily the result of a 20% underfulfillment of last fall's sowing plan. In addition, the lack of snow cover and below-normal temperatures in the last half of January probably caused above-average winterkill, but the USSR will probably offset the winterkill in part by using less winter grain than usual for

2. Appendix A sets out the several steps used in deriving the estimates; Appendix B presents the regression equations relating yields of the individual grains to time.

Table 1

Soviet Grain Area: Actual 1971 and Estimated 1973[1]

	Million Hectares of Harvested Area	
	1971	1973
Total	117.9	121.5
Winter wheat	20.7	16.3
Spring wheat	43.3	45.2
Winter rye	9.5	4.6
Corn	3.3	5.5
Spring barley	20.3	27.0
Winter barley	1.3	1.1
Oats	9.6	10.0
Millet	2.4	3.0
Buckwheat	1.8	2.0
Rice	0.4	0.4
Pulses	5.2	6.4

1. The distribution of harvested area, by grain, is not available for 1972. The distribution for 1971, while reflecting a normal pattern for fall-sown grains, does not show the major shift in spring-sown grains toward barley that was first observed in 1972. Because of rounding, components may not add to the totals shown.

spring forage. To recoup losses, the USSR probably will sow more than 100 million hectares to spring grains. The announced strategy is to emphasize barley, corn, and oats -- crops that generally provide a better yield than spring wheat.

8. The trends in yields and the projected distribution of harvested area imply a gross grain crop of 152½ million tons of usable grain in 1973 (see Table 2).[3] This forecast, however, is a

Table 2

USSR: Harvested Area, Yields, and Gross Production of Grain[1]

	Actual 1971			Projected 1973		
	Harvested Area (Million Hectares)	Yields (Centners per Hectare)	Gross Production (Million Tons)	Harvested Area (Million Hectares)	Yields (Centners per Hectare)	Gross Production (Million Tons)
Total	117.9		181.2	121.5		188.4
Winter wheat	20.7	23.1	47.8	16.3	22.0	35.9
Spring wheat	43.3	11.8	51.0	45.2	11.6	52.4
Winter rye	9.5	13.5	12.8	4.6	12.8	5.9
Corn	3.3	25.7	8.6	5.5	29.6	16.3
Spring barley	20.3	15.9	32.2	27.0	16.4	44.3
Winter barley	1.3	18.1	2.4	1.1	16.4	1.8
Oats	9.6	15.2	14.7	10.0	15.9	15.9
Millet	2.4	8.5	2.0	3.0	9.4	2.8
Buckwheat	1.8	6.6	1.2	2.0	7.7	1.5
Rice	0.4	36.7	1.4	0.4	39.5	1.6
Pulses	5.2	13.3	6.9	6.4	15.4	9.9
Total net usable production			148.0			152.6

1. Because of rounding, components may not add to the totals shown.

3. This is the net output equivalent of the 188½ million tons of gross output estimated in Table 2. Officially claimed gross production of grain is known to overstate usable grain because of excess moisture, trash, handling losses, and suspected biases in reporting. The average of estimated discounts from gross output during 1958-71 is 19%. This figure is applied to the projection of production in 1973.

point estimate to which a confidence interval must be attached. The confidence interval was calculated from estimates of the variances of each grain and the co-variances among grains. Thus the variations of each individual yield around the trend forecast were computed, and the forecast variance was calculated as a weighted sum of the variances for each grain, taking into account the degree to which yields of different grains fluctuate together. The point estimate of production and the lower and upper bounds at the 68% probability level for total grain and for bread grains are as follows:

Million Tons

	Forecast	Low	High
Total grain	152.6	133.1	172.1
Bread grain	76.3	64.5	88.1
Wheat	71.5	60.0	83.1

9. The production forecast for 1973, given "normal" weather and the expected sowing strategy, exceeds the record harvest of 150 million tons of usable grain in 1970. Nevertheless, the poor harvest of 1972 (134 million tons) is within the calculated confidence interval, as is a crop large enough to satisfy all foreseeable requirements for

grain. As wide as the range might appear (given the use of a 68% probability level in deriving the range of possible forecasts), there remains one chance in three that the 1973 crop could be either lower than 133 million tons or higher than 172 million tons.

10. The wide range of uncertainty in projected output reflects the wide fluctuations in annual yields. In the late 1960s, 45% of the total grain area in the USSR and 60% of the total wheat area was in a 21-oblast area where rainfall is marginal -- between 10 and 16 inches per year. Indeed, about three-fourths of the sown area in the Soviet Union has a climate similar to the Great Plains states of North Dakota, South Dakota, Nebraska, Montana, and Wyoming and the Prairie Provinces of Canada. These North American regions also have had a long history of wide cyclical swings in grain yields resulting from variations in weather conditions.[4]

4. Because of differences in farming practices, the cyclical swings in yields (as measured by the coefficient of variation) in the comparable area of the Soviet Union would be larger. Good land management in analogous areas of North America demands that 30% or 40% of the cultivated area be in clean fallow. In the USSR in 1971, only about 12% of cultivated acreage in the areas referred to were under clean [footnote continued on p.9]

Outlook for Soviet Demand for Grain

11. Because little information is published on the utilization of grain in the Soviet Union and statistics on stocks are closely guarded secrets, estimates of current consumption and projected requirements can only be approximated. Of the various uses of grain, the dispositions for seed, food, and industrial uses can be estimated with a reasonably high degree of confidence. Estimates of the grain flowing into the other channels of utilization -- waste and livestock feed -- and the change in year-to-year stocks are at best rough approximations.[5] Table 3 provides estimates of the grain balances for FYs 1971-73 and a tentative estimate of the demand for grain in FY 1974.

12. On the basis of assessed Soviet requirements for grain in FY 1974, the demand for food, seed, and industrial use is expected to come to roughly 86½ million tons, the same as in FY 1973. The allowance for waste and assumed inventory change

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fallow. (Under the practice of clean fallowing the land is not planted and is cultivated only as needed to suppress weeds. The practice also permits accumulation of moisture in the soil.)

5. In deriving the residual available for additions to stocks or livestock feed, an allowance of 3% is used for waste. This waste factor covers losses after the initial stage of harvesting and storage.

Table 3

USSR : Estimates of Grain Supply and Demand

Million Metric Tons

	Supply of Grain			Demand for Grain					
	Net Production	Imports	Total	Exports	Food, Seed, and Industrial Use	Waste	Inventory Change	Livestock Feed	Total
FY 1971	150	3	153	8	85	4½	1	54½	153
FY 1972	148	8	156	8	87½	4½	-3½	59½	156
FY 1973	134	26	160	6	86½	5	0	62½	160
Projected FY 1974	152½	12½-17½	165-170	6	86½	5	0	67½-72½	165-170

in FY 1974 also imply no change from the FY 1973 level. Although the USSR is trying to reduce its exports of grain -- particularly to client states in Eastern Europe -- it probably will not succeed in cutting its deliveries below last year's level of 6 million tons. Indeed, as a result of record grain crops in Eastern Europe in 1972, the USSR was able to reduce its grain exports to Eastern Europe from 5 million tons in FY 1972 to 3 million tons in FY 1973. If output should slip in these countries in FY 1974, the Soviet Union will be under considerable pressure to supply more than 3 million tons of grain.

13. The upsurge in the use of grain for livestock feed, a consequence of the official campaign

initiated in 1969 to alleviate meat shortages is the principal cause of the Soviet grain problem. Since 1969, requirements of the livestock program have outstripped the supply of feed grains and have eroded seriously the USSR's reserve stocks of wheat. In 1969, an estimated 9 million tons of wheat were released from government stocks for feeding livestock in 1970.[6] The use of wheat reserves for livestock feed is believed to have reduced them to near the level considered vital as a strategic reserve. Indeed, the major imports of grain in FY 1972 and FY 1973 indicate that grain stocks have been drawn down to minimal levels.[7] Matching the FY 1973 supply of grain with the requirement for export, food, seed, industrial use, and waste leaves a residual for livestock feed of more than 62 million tons. This magnitude, in turn, would be three million tons more than the grain fed to livestock in FY 1972 and 20 million to

6. In the last few years, about 20 million tons of wheat have been fed to livestock annually.
7. That is, inventories held as buffer stocks to minimize the effects of harvest shortfalls. In addition to stocks to cover normal requirements, some unknown quantity of inventories of grain is held for strategic purposes to supply the military forces and the economy in time of extreme emergency. Presumably, at the point when total grain reserves consist solely of strategic stocks, the regime will feel compelled to authorize imports.

25 million tons higher than the amount fed in FY 1968.

14. The demand for grain for livestock feed is thus the key element in projecting the total Soviet demand for grain in FY 1974. In December the Central Committee approved livestock goals for 1973 that will maintain overall livestock production at approximately the 1972 level while permitting a 5% reduction in meat output. The emphasis in 1973 will be on rebuilding herds and recovering previous levels of productivity. As a result of the bad harvest of 1972, inventories of hogs declined and a downturn in output of milk and meat per animal occurred in the last half of 1972. The USSR has made it clear, however, that it still hopes to meet the ambitious goals for livestock products originally set for 1975 (see Table 4). Even to come close to achieving these goals, livestock output will have to rise dramatically during 1974 and 1975. Because production from the 1974 crop will not be available in volume for feeding livestock until August-September 1974, the level of livestock production in 1974 will depend in large part on grain

Table 4

USSR: Production of Livestock Products

	Calendar Year					Annual Average Increase in 1973 and 1974 Required to Meet 1974 Plan
	Actual			Plan		
	1970	1971	1972	1973	1974	
Meat (million tons, slaughter weight)	12.1	13.2	13.6	12.9	16.0	1.6
Milk (million tons)	81.0	83.2	83.2	86.2	100.0	6.9
Wool (thousand tons)	419.0	429.0	419.0	434.0	500.0	33.0
Eggs (billion)	40.7	45.1	48.2	47.5	57.0	2.2

supplies from the 1973 crop and from imports in FY 1974.[8]

15. To support the livestock program, therefore, the USSR will have to increase the amount of grain fed to livestock. We estimate this increase to be 5 million-10 million tons in FY 1974. The lower end of the range assumes that:

- Production of non-grain feedstuffs (silage, hay, pasture, other concentrates, etc.) in 1974 will recover from the drought-affected 1973 level but will not exceed the average for 1970 and 1971.
- The recent emphasis on increasing the number of hogs and poultry, whose

8. Selected non-grain feeds produced in 1974 -- pasture and green chop -- would normally be available by June-July; other feeds -- oilseed cake and silage -- would not be available in volume until September.

rations are composed largely of grain, will continue.

- The USSR will have to raise the proportion of grain in livestock rations to achieve badly needed gains in feeding efficiency and reduced costs.
- The planned 5% reduction in meat output in calendar year 1973 in comparison with calendar year 1972 will be evenly distributed throughout the year.

16. The upper end of the range modifies the last assumption above to the extent that:

- The 5% decrease in meat output slated for 1973 is concentrated in the first six months of the year to achieve a simultaneous rapid buildup of herds.

17. This assumption would provide for a higher average level of livestock inventories throughout FY 1974 in order to sustain a more rapid advance in output of meat in 1974 and 1975.[9]

9. In other words, numbers of livestock would rise at a rate during the first half of 1973 that would require a decline of more than 5% in meat production in comparison with the corresponding period in 1972. This would be followed by a higher level of meat output in the last half of the year.
This interpretation of official strategy in regaining the forward momentum in meat production is supported by the figures for industrially processed meat in the first two months of 1973 -- down 10% from the corresponding period in 1972.

18. Thus the USSR's requirements for grain add to about 165 million-170 million tons, the range reflecting the above alternative. In the unlikely event that production would be precisely 152½ million tons -- the point estimate with normal weather -- the USSR would need to import 12½ million-17½ million tons of grain to meet its requirements fully. It should be noted, moreover, that these estimates allow for no replenishment of grain reserves, which are believed to be minimal now. If, as seems likely, the Soviet Union decides to set aside additional tonnage this crop year as buffer stocks, the import requirement would rise accordingly. Nevertheless, because the range of possible production is so wide, there is a reasonable chance that the USSR would not have to import any grain at all or, alternatively, that it would need to purchase much more than 17½ million tons from abroad. With a crop of 140 million tons or less -- a distinct possibility given the wide range of possible outcomes -- the leadership would probably choose to make painful adjustments in its present farm and consumer policies to avoid paying the enormous sums of hard currency that would be necessary to buy grain in the quantities ordered in FY 1973.

APPENDIX A

Procedures for Forecasting Soviet Grain Production

1. The first step in predicting Soviet production of grain was to estimate a set of regression parameters (a_i, b_i), $i=1,\ldots,11$, such that for each of 11 grains, annual yields per harvested hectare in 1958-71 were related to time[1]:

$$Y_{it} = a_i + b_i t + \varepsilon_{it}, \tag{1}$$

where ε_{it} denotes the usual disturbance term in regression analysis. The regression equations are shown in Appendix B. Plots of the actual yields and the estimated trend are shown for each grain.

2. Total production for each year

$$t = 1,2,\ldots,14$$

corresponding to 1958,..., 1971 was then estimated as

$$ET_t = \sum_{i=1}^{11} (a_i + b_i t) A_{it}, \tag{2}$$

where the set (A_{it}) consists of harvest areas. Since the reported actual totals

$$(ACTUAL_t,\ t=1,\ldots,14)$$

are known, a set of prediction errors was computed:

1. The regressions were done with official Soviet claims of gross yields. When aggregated to production, a uniform discount of 19% was applied to estimate usable grain. Alternatively, the yield data could have been adjusted by the appropriate discount for each year.

(3) $$DEV_t = ACTUAL_t - ET_t.$$

The relationships of estimated and actual production for total grain and for breadgrain can be seen in the charts in Appendix C.

3. The maximum absolute deviation, measured in million metric tons, is 33.2 for 1963; and the average absolute deviation is 10.8 million tons. The sum of deviations is 2.2 million tons, indicating no substantial bias toward errors of one sign. When each absolute deviation is divided by the corresponding actual total production, the average of these is 10%. The root mean square error, computed as:

(4) $$RMSE = [(1/14) \sum_{t=1}^{14} (DEV_t)^2]^{1/2},$$

is 14.2 million tons. For breadgrains, the average absolute deviation is 8.2 million tons, the average percentage deviation is 12%, and the root mean square error is 9.9 million tons.

4. Thus a rough estimate based on the statistics presented above is that the total forecast of 152.6 million tons for 1973 is accurate with a probability of 0.68 within the range ±15 million tons. For breadgrains the 68% prediction interval similarly would be ±10 million tons about the 1973 forecast of 76.3 million tons. A more rigorous procedure outlined below gives 68% prediction

intervals of ±19.5 million tons in total grain and ±11.8 million tons for breadgrains, thereby corroborating the intuitive estimates.

5. The main difficulty impeding a simple but rigorous derivation of prediction intervals for grain aggregates is that the regression equations for each grain are what Theil[2] calls "disturbance-related"; in particular, weather cycles introduce contemporaneous correlations among the error terms (ϵ_{it}). To deal with this difficulty, we shall extend a result derived by Hooper and Zellner.[3] In their notation, our regression model becomes:

$$(5) \qquad y(i,n) = \sum_{k=1}^{2} \beta(i,k)x(k,n) + v(i,n),$$

where $y(i,n)$ is the yield per hectare of the ith grain in the nth year, such that $n = 1$ corresponds to 1958; $x(k,n)$ is the kth regressor value during the nth year, such that $x(1,n) = 1$ for all n, and $x(2,n) = n$; $\beta(i,k)$ is the regression coefficient for the kth regressor in the ith equation; and $v(i,n)$ is the error term in the ith equation for the nth year.

2. Henri Theil, Principles of Econometrics, New York, 1971, p. 297.
3. John Hooper and Arnold Zellner, "The Error of Forecast for Multivariate Regression Models," Econometrica, Vol, 29, No. 4, October 1961.

6. In matrix notation, the model is:

(6) $$Y = \Pi X + V,$$

where $\underline{Y}$ represents an (11x14) matrix of the 14 sets of sample values of yields per hectare for the 11 types of grain; Π is an (11x2) matrix of unknown regression coefficients; $\underline{X}$ is a (2x4) nonstochastic matrix of values taken by the independent variables; and $\underline{V}$ is an (11x14) matrix of error terms. We assume that the 14 columns of $\underline{V}$ are independent random draws from an 11-dimensional normal (Gaussian) population, such that each column has a zero expected value, and columns have a common covariance matrix $\Sigma(v,v)$. These conditions may be summarized as:

(7) $$E(v(i,n)) = 0 \text{ for all } \underline{i} \text{ and } \underline{n}, \text{ and}$$

(8) $$E(v(i,n)v(j,n')) = \begin{cases} 0, & n \neq n' \\ \sigma(i,j), & n = n'. \end{cases}$$

Thus we allow for correlation among error terms in different equations in the same year, but not among random terms of different years.

7. By regressing the yields per hectare of each grain on a constant term and on time for 14 years, we can obtain a matrix of regression coefficients $\underline{P}$, such that

(9) $$Y = PX + \bar{V},$$

where $\hat{V}$ is the matrix of observed error terms. Our forecast vector of yields per hectare for a future year f is then:

(10) $$Y^*(f) = PX(f),$$

where X(f) denotes the (2x1) column vector (1,f)'.

8. The observed value of yields per hectare in the future year will be:

(11) $$Y(f) = \Pi X(f) + V(f),$$

such that the error of forecast will be:

(12) $$Y^*(f) - Y(f) = (P - \Pi)X(f) - V(f).$$

To estimate the forecast covariance matrix $\Sigma(f,f)$, Hooper and Zellner[4] suggest that we compute:

(13) $S(v,v)$ as $(YY' - PXX'P')/(14 - 2)$, and

(14) q as $X(f)'(XX')^{-1}X(f)$.

An unbiased estimator $S(f,f)$ of $\Sigma(f,f)$ is then:

(15) $$S(f,f) = (1 + q)S(v,v).$$

9. To get the confidence interval we want for total production, we can define the (11x1) column vector A as sown acreages for the forecast year, and then define:

(16) $$t^2 = (A'(Y^*(f) - Y(f)))^2/A'S(f,f)A.$$

This t value has the Student's "t" distribution with (14 - 2) degrees of freedom, as can be seen from the following two arguments.

4. Op. cit., p. 550.

10. First, the numerator in (16) is the square of a normally distributed scalar value since $(Y^*(f) - Y,(f))$ is multinormally distributed with mean $\underline{0}$ and covariance $\Sigma(f,f)$. Thus the square root of the numerator can be standardized by dividing it by the square root of the scalar $A'\Sigma(f,f)A$.

11. Second, Hooper and Zellner[5] argue that $(14 - 2)S(f,f)$ is distributed as the sum of $(14 - 2)$ vector products, i.e., as:

$$(17) \qquad \sum_{n=1}^{12} s(n)s(n)',$$

where $s(n)$ is an $(11x1)$ vector, and where the $s(n)$ vectors are distributed normally and independently of each other, each having a $\underline{0}$ expected value and a covariance matrix $\Sigma(f,f)$. Thus if we define:

$$(18) \qquad D^2 = ((14 - 2)A'S(f,f)A) \cdot A'\Sigma(f,f)A,$$

then D^2 is a chi-square variate with $(14 - 2)$ degrees of freedom.

12. Thus the t^2 value in (16) is a squared normal variate divided by the ratio of a chi-square variate over the variate's degrees of freedom. Since this corresponds to the definition of a "t" variate, we can use the probability relation:

$$(19) \qquad Pr(|t| > t_a) = a$$

5. Ibid.

to derive confidence intervals about the total production forecast Y(f), and also about the total breadgrain forecast B(f). In particular, we can be 68% confident that Y(f) will be in the interval 152.6 $\pm$ 19.5. Similarly, forecast breadgrain production will be in the interval 76.3 $\pm$ 11.8 with probability 0.68.

APPENDIX B

USSR: Linear Regressions on 1958-71 Yield Trend and Forecasts of Grain Yields in 1973

	Regression Equation[a]			1973 Yield Forecast[b] (Centners per Hectare)	Standard Error of Forecast
	Constant	Trend	R^2		
Winter wheat	13.38 (11.2)	0.54 (3.9)	0.55	22.0 (17.8)	2.5
Spring wheat	7.73 (6.9)	0.24 (1.9)	0.22	11.6 (9.4)	2.3
Winter rye	8.20 (12.5)	0.29 (3.8)	0.54	12.8 (10.4)	1.4
Corn	18.67 (10.8)	0.69 (3.4)	0.49	29.6 (24.0)	3.6
Spring barley	9.67 (8.8)	0.42 (3.3)	0.47	16.4 (13.3)	2.3
Winter barley	13.75 (11.8)	0.17 (1.2)	0.11	16.4 (13.1)	2.4
Oats	6.52 (7.5)	0.59 (5.7)	0.73	15.9 (12.9)	1.8
Millet	6.37 (7.6)	0.19 (1.9)	0.23	9.4 (7.6)	1.8
Buckwheat	2.90 (4.7)	0.30 (4.1)	0.59	7.7 (6.2)	1.3
Rice	16.72 (19.2)	1.43 (14.0)	0.94	39.5 (32.1)	1.8
Pulses	7.27 (9.6)	0.51 (5.7)	0.73	15.4 (12.5)	1.6

a. t values in parentheses. A t value of 1.8 or higher indicates significance at the 5% level.
b. Yields expressed on a gross "bunker weight" basis. Yields in parentheses are uniformly discounted by 19% – the average for all grains in 1958-71 – to roughly convey the net yield of all grain per hectare.

APPENDIX C

Prediction of Soviet Production From Trends in Yields, 1950-71 (Figures 1 and 2)

Predicted production shown in the charts is the sum of the products of trend yield and actual harvest areas for each grain. The wide variation in yields as suggested in Appendix D, coupled with the annual changes in sown acreage patterns, results in a large fluctuation in the plot of predicted total outputs over time.

Figure 1

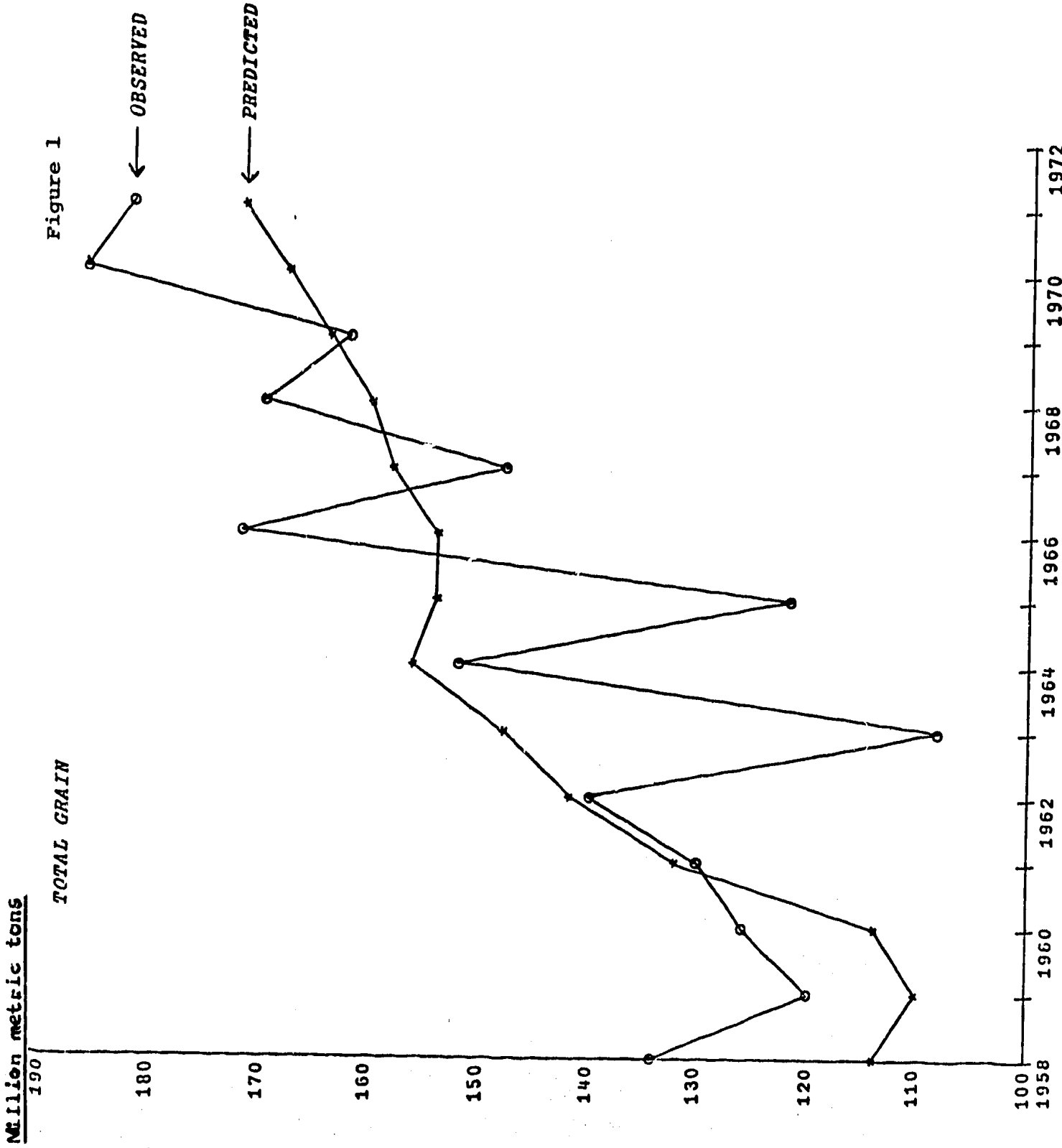
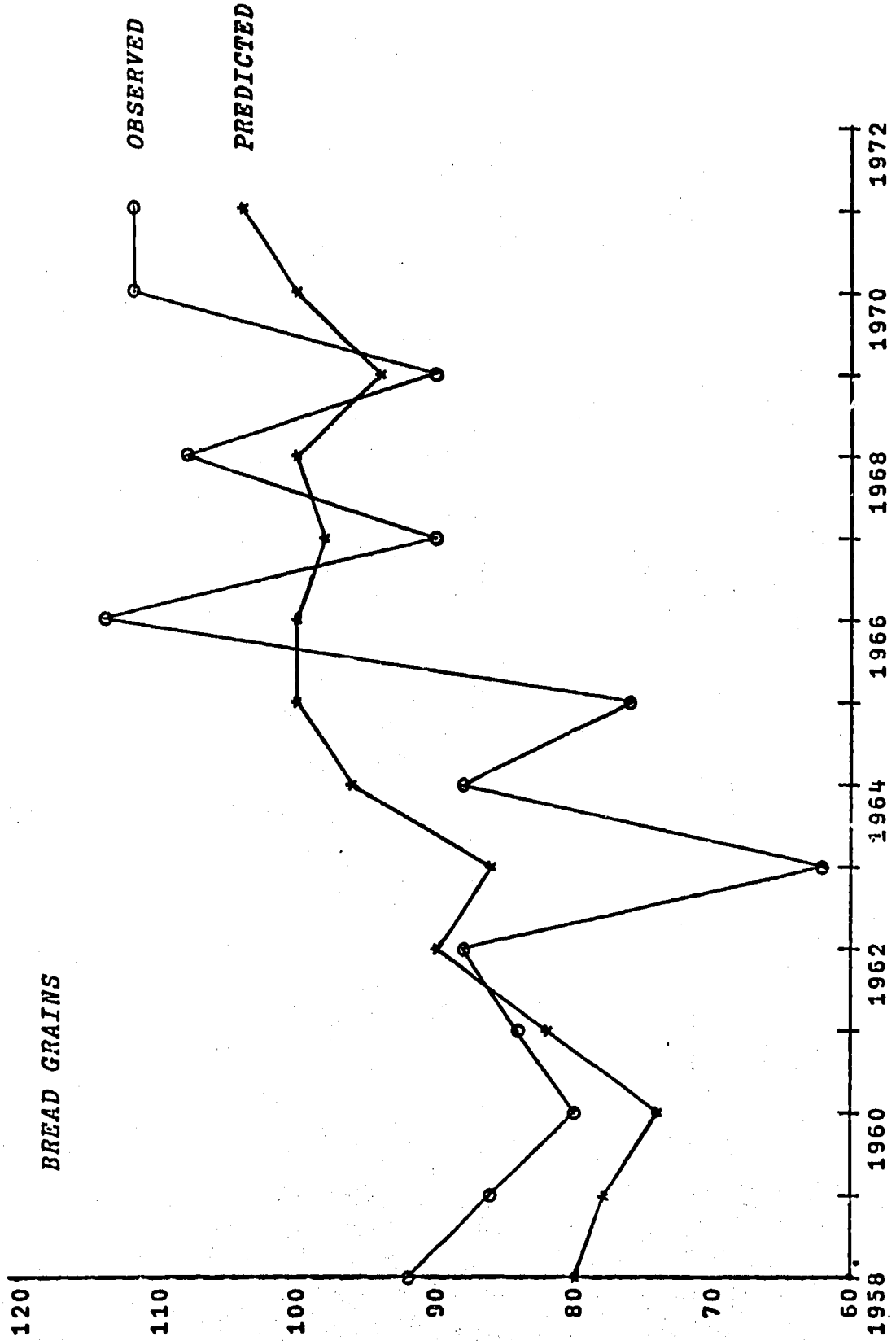


Figure 2



APPENDIX D

Yields of Individual Soviet Grains, 1958-71, and Linear Estimation of Trend (Figures 3-13)

Yields are expressed in centners per hectare of harvested acreage and reflect official claims -- i.e., they are given on a "bunker weight" basis. In 1958-71 the ratio of usable grain to grain in bunker weight averaged 0.81.

Figure 3

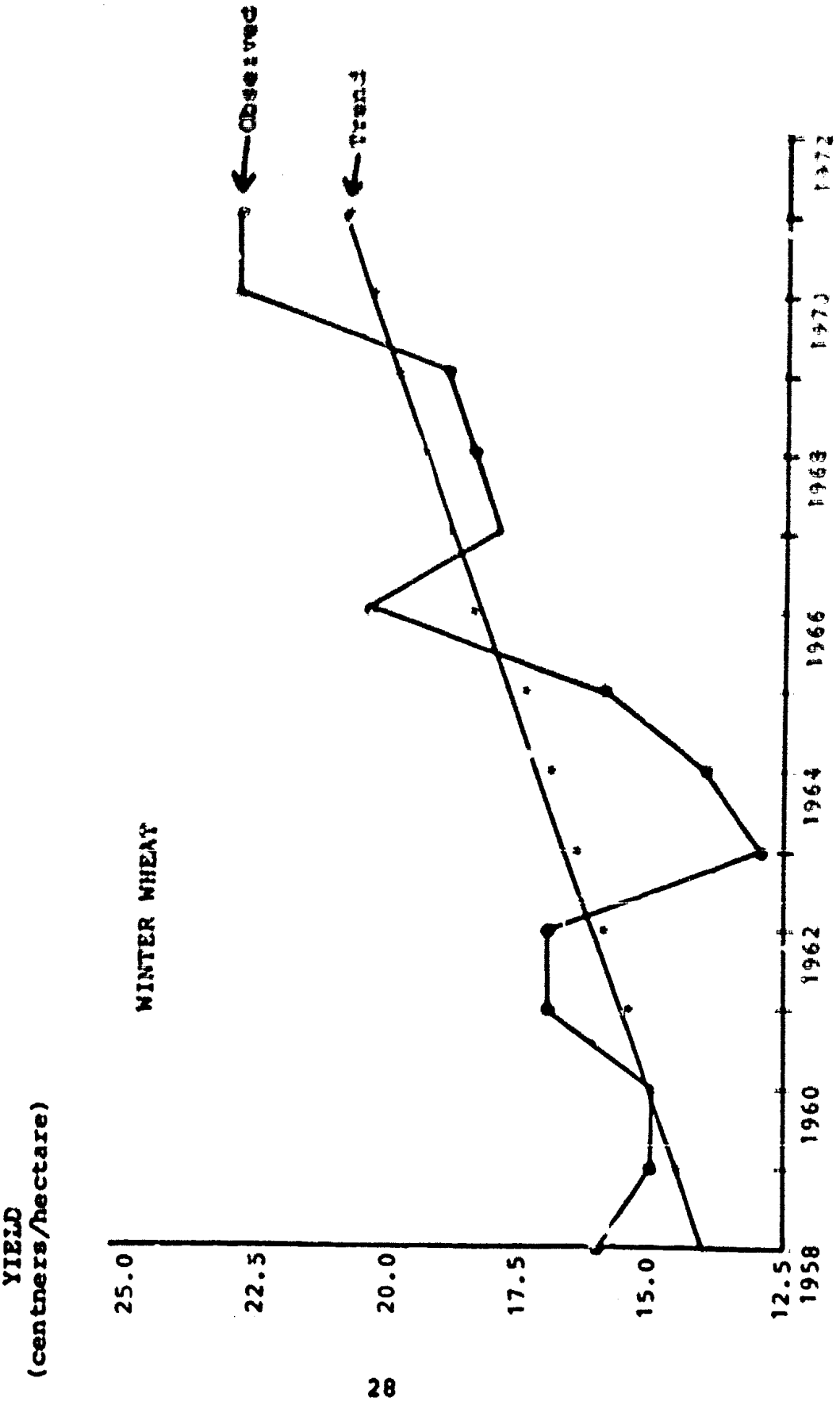


Figure 1

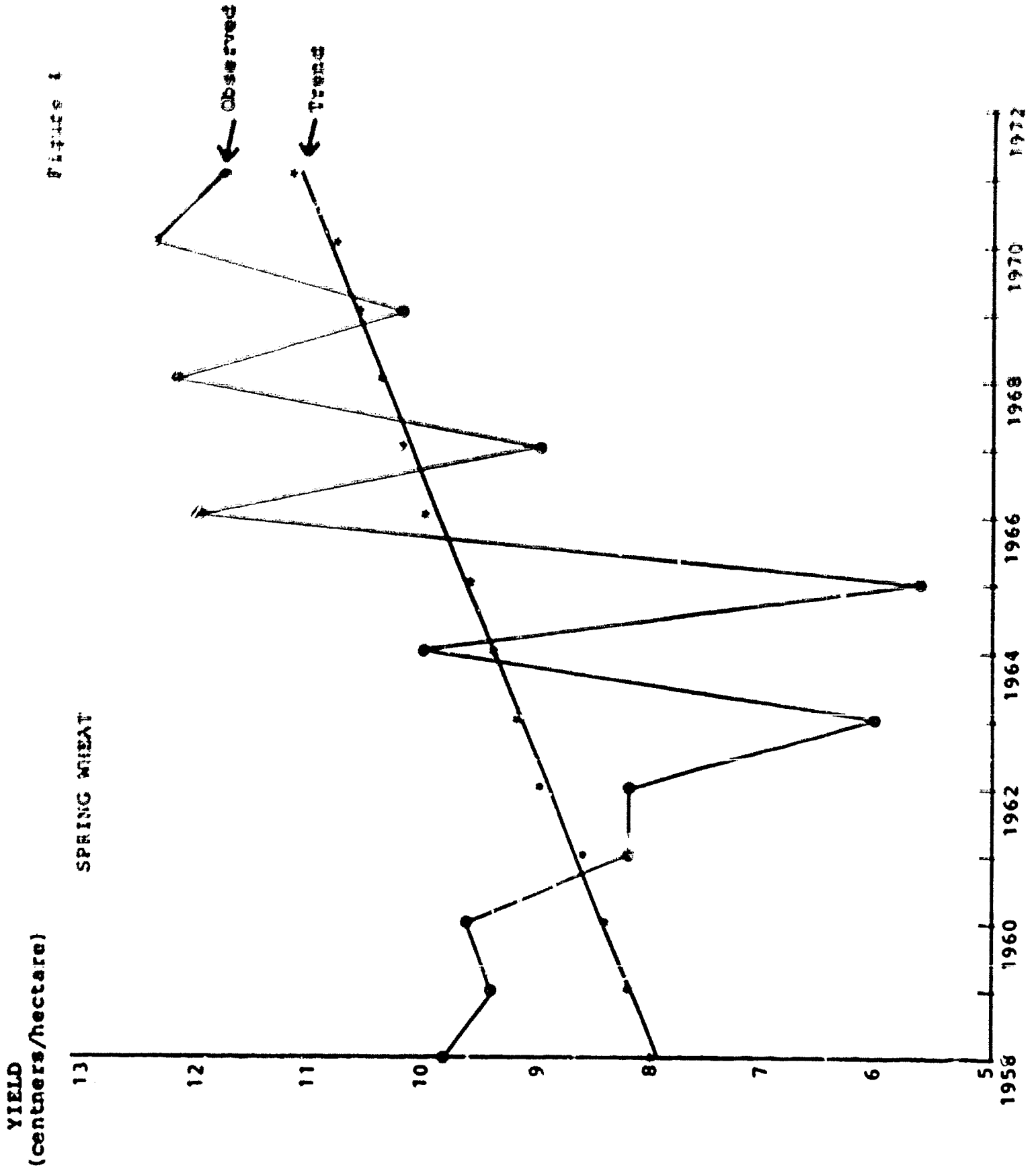


Figure 1

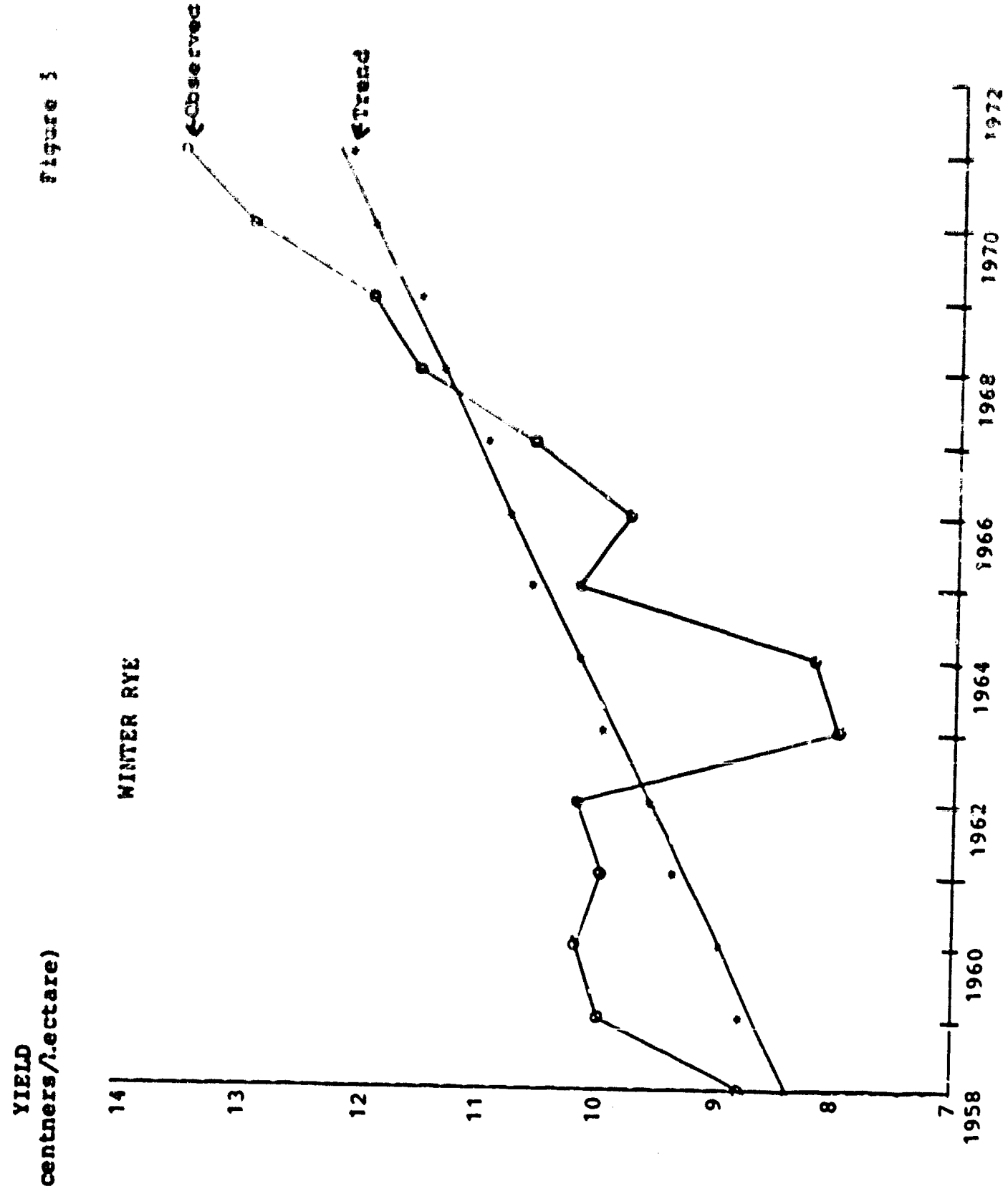


Figure 6

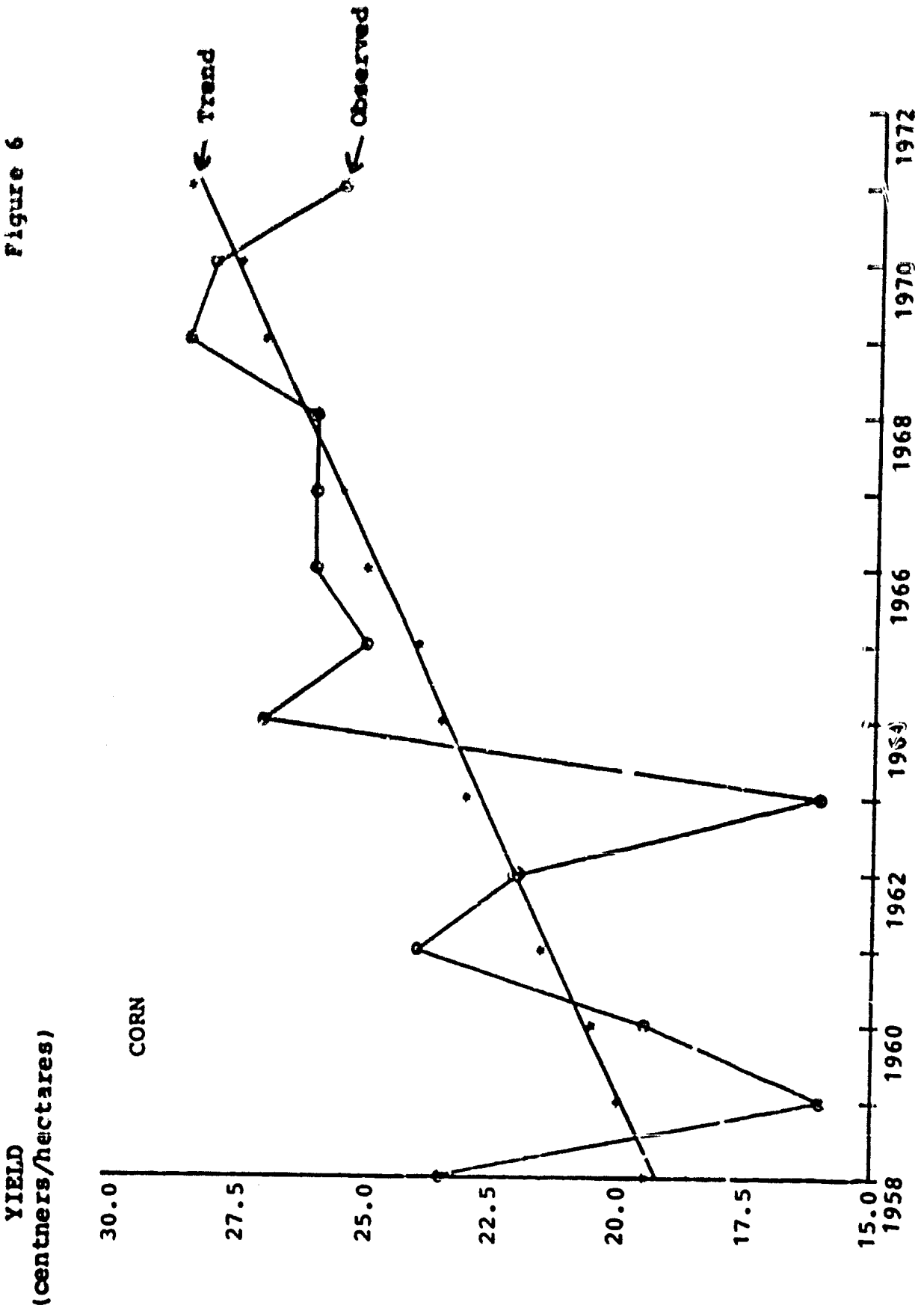


Figure 7

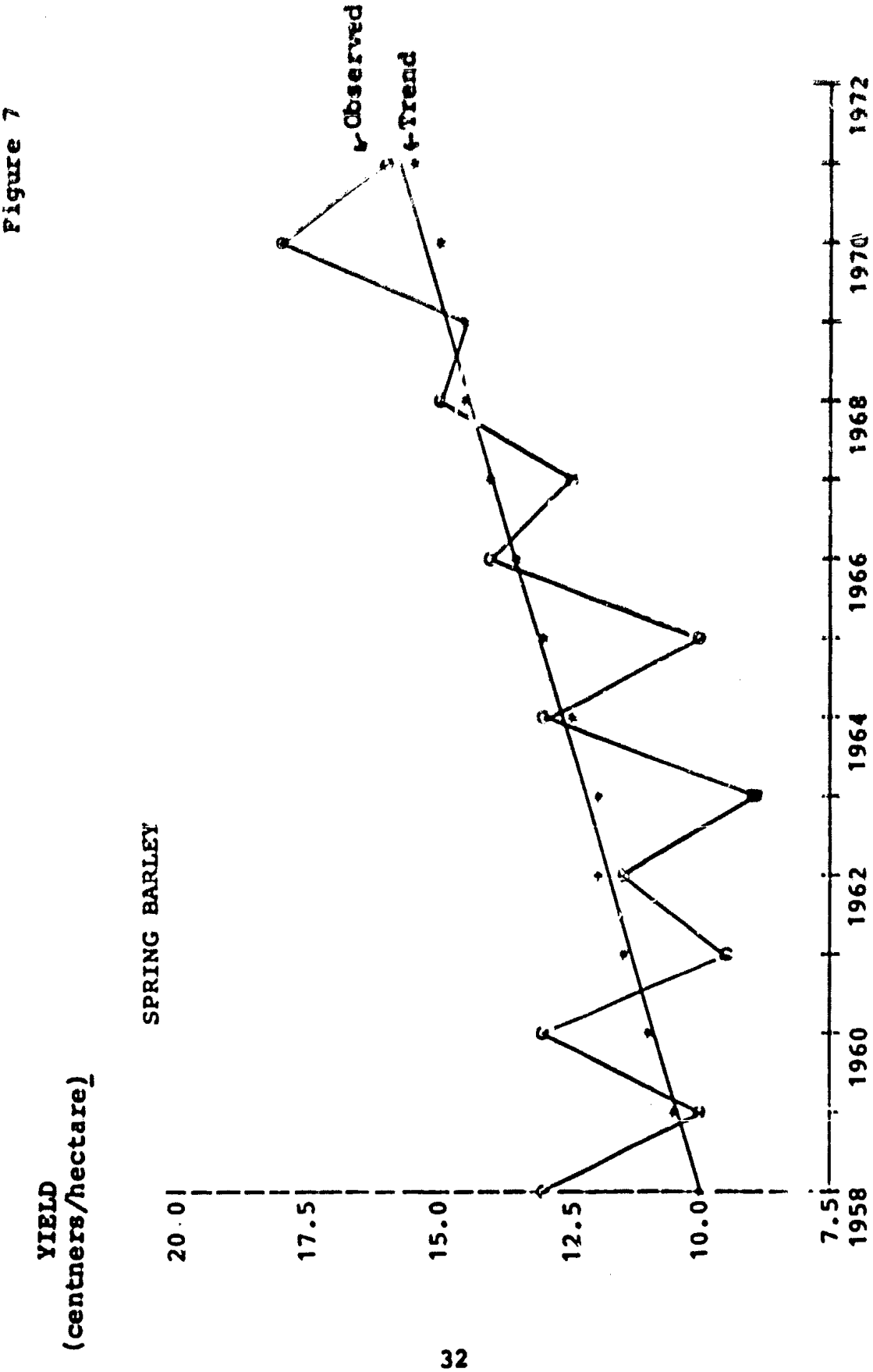


Figure 8

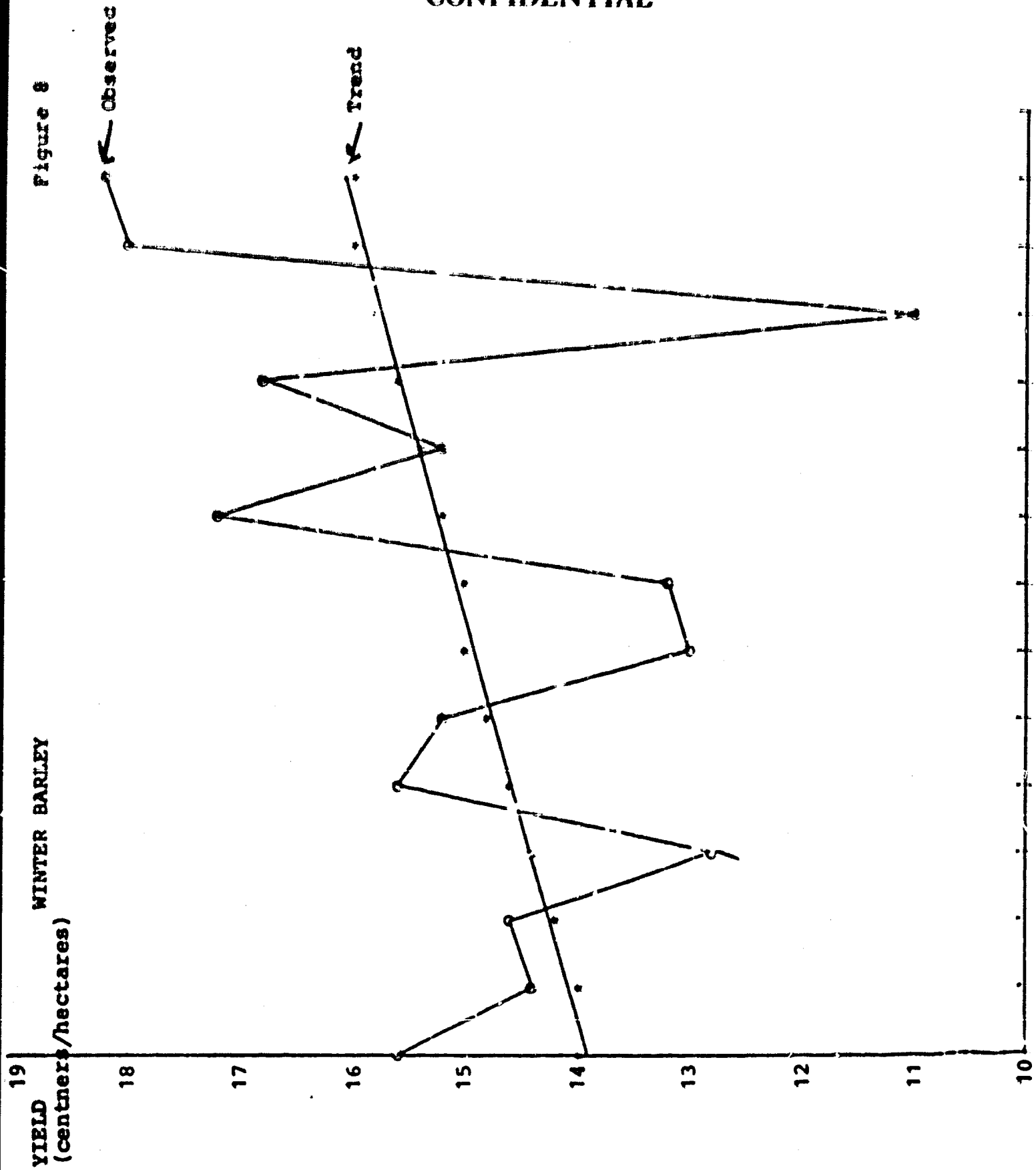


Figure 9

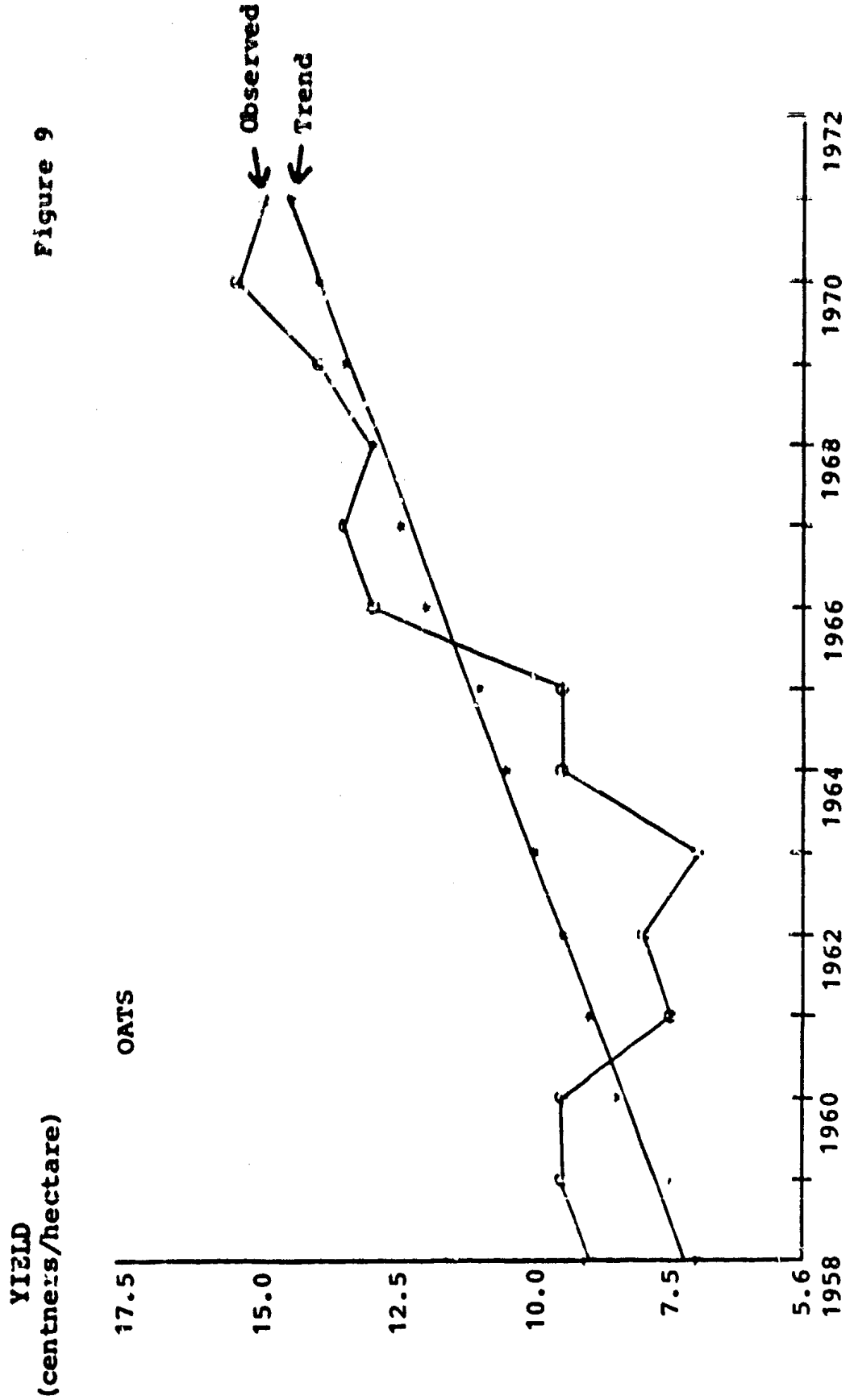


Figure 10

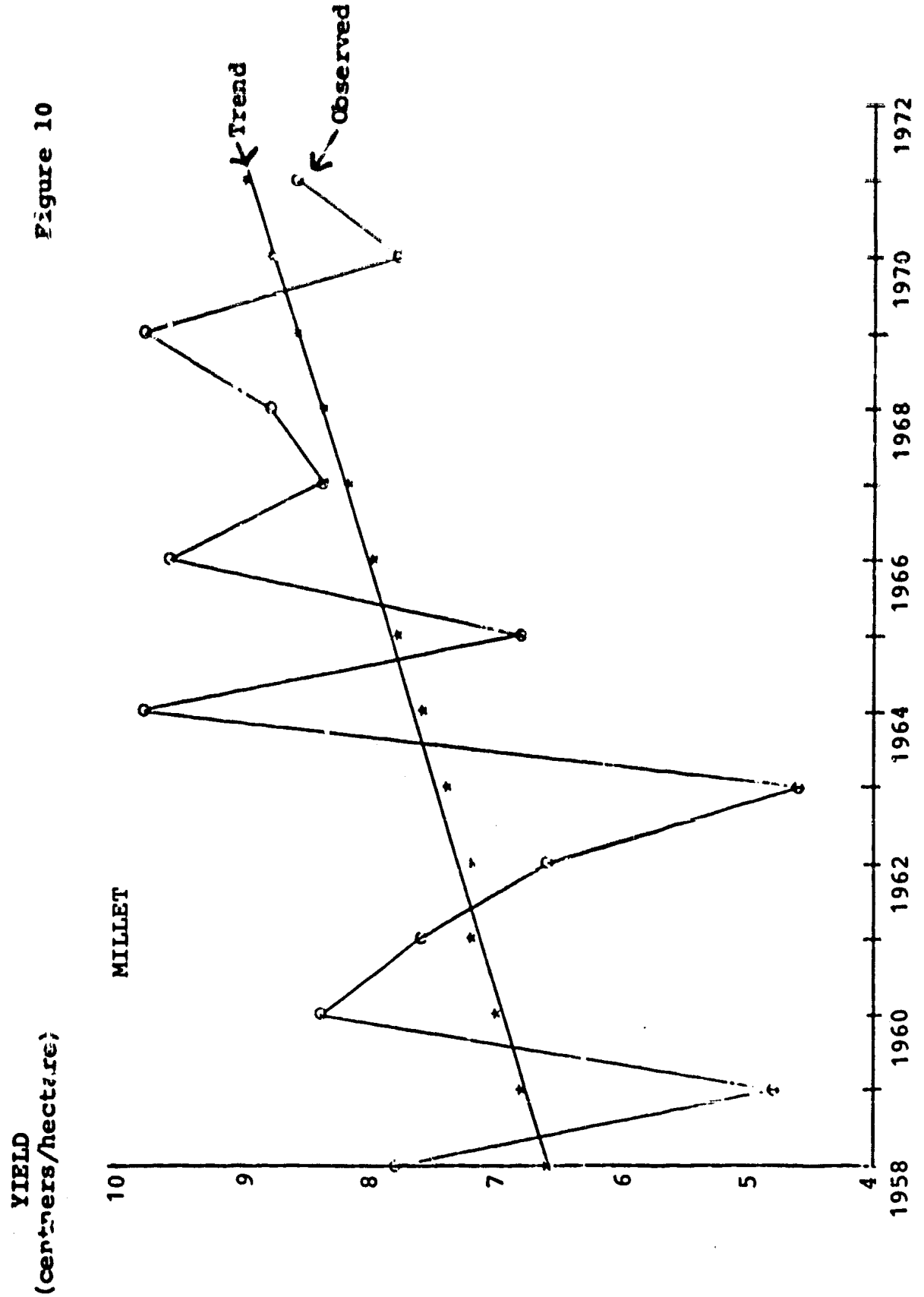


Figure 11

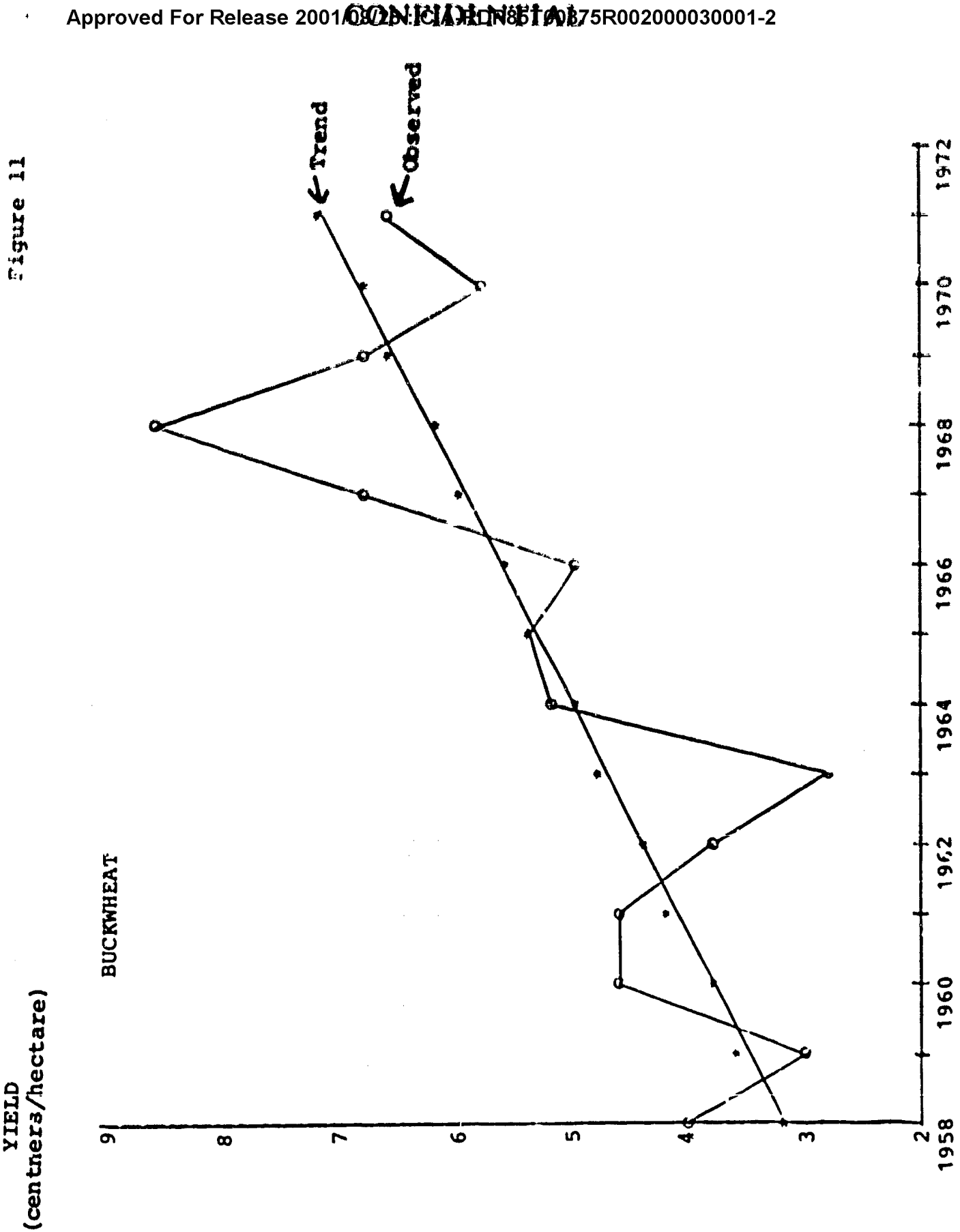


Figure 12

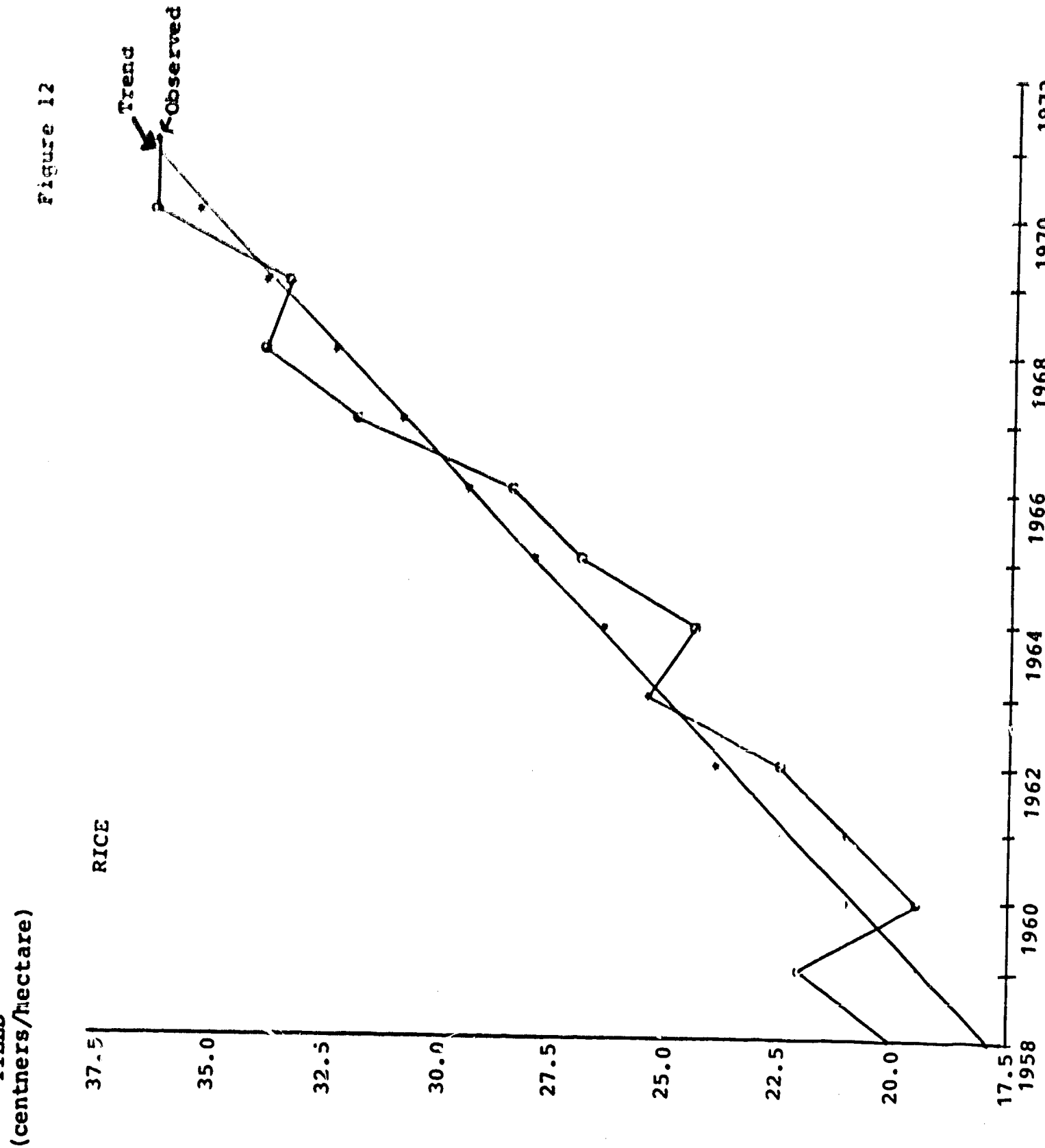
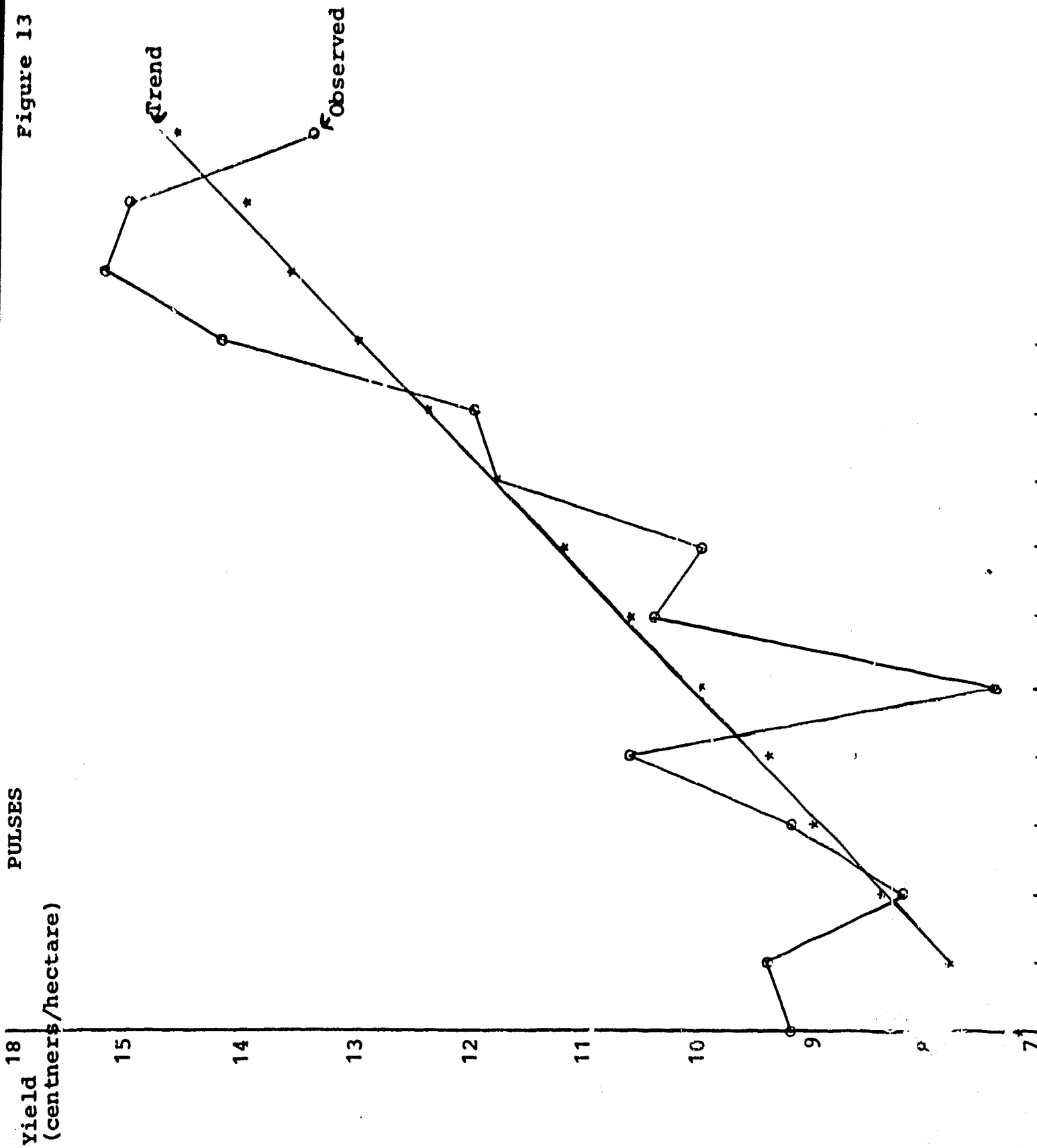


Figure 13


Trend
Observed
PULSES
Yield (centners/hectare)
18
15
14
13
12
11
10
9
8
7